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Description

ARRANGEMENT IN A PIPE JOINT FOR A HEAT EXCHANGER

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation patent application of International Application No. PCT/SE02/00959 filed 17 May 2002 which was published in English pursuant to Article 21(2) of the Patent Cooperation Treaty, and which claims priority to Swedish Application No. 0101797-9 filed 21 May 2001. Both applications are expressly incorporated herein by reference in their entireties.

BACKGROUND OF INVENTION

TECHNICAL FIELD

[0002] The present invention relates to an arrangement in a pipe joint for a heat exchanger also termed a recuperator that is adapted for use with a gas turbine for stationary use in a small scale combined power and heating plant or for

mobile use in a vehicle.

Background Art

[0003] A heat exchanger of the type may be used in, for example, a combined power and heating plant, for mobile use or in a reserve power station. For many such applications it is of vital importance that the recuperator is designed in such a way that is as efficient as possible, while minimizing weight and dimensions. The recuperator may, for instance, be made up of a plate heat exchanger comprising a number of plates manufactured from very thin sheet metal, generally having a thickness of about 0.1 mm. The plates are provided with corrugations in a known manner, whereby they are stabilized relative to each other in a wave shaped pattern. Spaces between the corrugations will then form flow channels for a heat emitting medium and a heat-absorbing medium. If a gas turbine is used, the heat-emitting medium is combusted gases leaving the turbine, while the heat-absorbing medium is usually air.

[0004] As the heat emitting and absorbing media may have a relatively high temperature, problems may arise in tubing and pipe joints of such systems. When starting a plant using a gas turbine, the temperature in the component parts will rise from ambient temperature, for example 20°C, to

temperatures in excess of 600°C. This usually entails large thermal loading due to heat expansion in different parts of the system. In operation the variations in temperature between different parts of the plant are less, but may still cause problems.

[0005] At pipe joints between two sections of a heat exchanger, or between a source of heat and the heat exchanger, for instance between a gas turbine having exhaust gases requiring cooling, it may therefore be necessary to absorb forces that arise due to the fact that the heat exchanger packet and the pipe joint are very likely to have different coefficients of heat expansion. For this reason, welded or soldered joints in pipe systems without the capability of absorbing thermal loading are totally unsuitable, as repeated thermal loading will quickly give rise to cracks and leaks. Corresponding problems will also arise should mechanical joints, such as bolted connections, be used.

[0006] One solution, though deficient, is shown in Figure 2 that includes an inlet pipe connection 2 for conducting a heat emitting medium 6 to the heat exchanger. According to this example, the combusted exhaust gas, at a temperature of about 650°C and a pressure of about 1.1 bars, is conducted from a gas turbine to the inlet pipe connection

2 and into the heat exchanger. In the heat exchanger, a heat absorbing medium 7, such as air, is heated by the exhaust gases, whereby the air leaves the heat exchanger through the outlet pipe connection 3 at a temperature of about 610°C and a pressure of 4 bar. The lower end A of the inlet pipe connection 2 is mounted with a force fit onto a corresponding recess in a flange on the heat exchanger. The lower end A can be provided with a number of radial grooves C around its periphery, in order to increase the contact pressure between said end and the recess B. The grooves C may also be provided with sealing devices of suitable kind. Thermal loading caused by, for instance, axial expansion of the inlet pipe connection must be absorbed by the joint, therefore the component parts must be movable relative to each other.

[0007] In addition to its sensitivity to uneven loading, both during and after assembly, the arrangement may also have a certain leakage flow L_F between the inlet and outlet parts. The leakage flow is partly due to the pressure difference and partly due to poor fitting and relative movement between the component parts. Such a leakage will lower the efficiency of the heat exchanger.

[0008] Hence one problem is to achieve a pipe joint that can be

deformed in order to absorb thermal loads without being damaged. Depending on the positioning and assembly of the pipe joint, it may have to absorb movement in both axial and radial direction, in relation to the main axis of the pipe joint.

[0009] A further problem is the fit of such a pipe joint between two fixed points, where variations in fit and tolerance between the component parts of the heat exchanger may sometimes occur. In such cases it is also desirable to have a pipe joint that is deformable in several directions.

SUMMARY OF INVENTION

[0010] The purpose of the current invention is to eliminate problems associated with known solutions, thereby fulfilling the desired objectives of an improved pipe arrangement for a heat exchanger, as well as providing a simple and inexpensive arrangement for this purpose.

[0011] The purpose(s) of the invention are achieved by means of a pipe arrangement for heat exchangers and relating to pipe joint(s) for the heat exchanger which comprises (includes, but it not limited to) a number of corrugated plates. Each plate has a first edge part opposite a second edge part and a third edge part opposite a fourth edge part. Between the corrugated plates there are provided

first and second flow channels, where a heat emitting medium flows through every alternate channel and a heat absorbing medium flows through every other alternate channel. A collecting channel for heat emitting medium, which channel has a diverging cross-section, is placed at one side of the heat exchanger and is provided with an inlet section connected to a combined inlet and outlet pipe connection for the heat emitting and heat absorbing media. In addition, an outgoing collection channel for the heat-absorbing medium is arranged on the same side of the heat exchanger and has an outlet section connected to the inlet and outlet pipe. The inlet pipe comprises a deformable first pipe section, arranged to absorb thermal and mechanical movements in both axial and radial directions, and at least one further pipe section. The deformable section is preferably, but not necessarily, elastically deformable. According to one embodiment, the heat exchanger can co-operate with a gas turbine, whereby its combusted exhaust gases are used as the heat-emitting medium.

[0012] According to a one embodiment, the inlet pipe connection has a deformable first pipe section made up of a substantially cylindrical pipe, with walls having a corrugated

cross-section in the axial direction of the pipe. Such an embodiment can as a rule entail certain flow losses. In order not to limit or disturb the flow through the pipe joint, the average diameter, that is the average of the inner and outer diameters of the corrugations, should be larger than the inner diameter of the adjoining second pipe section. Preferably, the inner diameter of the deformable first pipe section, corresponding to the smallest diameter of the corrugated section, is equal to the inner diameter of the second pipe section. The cross-section of the corrugated section may be varied depending on the size and direction of the thermal movements to be absorbed. One example of a suitable shape is a sinusoidal cross-section, where the amplitude and wavelength can be varied to give the desired properties with respect to deformability in the axial and radial directions. The first pipe section is preferably elastically deformable.

[0013] According to an alternative embodiment, where the inlet and outlet pipe joints are arranged concentrically, it is further possible to distribute the flow losses between inlet and outlet. In this case, the average diameter of the corrugated section, that is the average of the inner and outer diameters of the corrugations, can be equal to the inner

diameter of the adjoining second pipe section.

[0014] A corrugated section as described above can be manufactured, for instance, by means of rolling, for metallic materials, injection molding, for plastic materials, or winding, for composite material. Apart from the choice of material, the resistance to deformation of the first pipe section is decided by the relative axial distance and radial amplitude of the corrugations, as well as the material thickness. These variables are selected with respect to the desired diameter of the pipes, the maximum deformation caused by thermal loading, and the temperatures and pressures to be handled by the pipes. Deformation of the corrugated section in its axial direction will mainly occur during changes of temperature in connection with start-up and operation of the plant, while deformation in its radial direction will mainly occur during assembly and fitting of the pipe joint. By making the pipe section elastically deformable, it will be able to absorb movements in the same way as a spring. Hence the section will absorb movements between the pipes without transmitting forces to any greater extent. In order to enable the deformations, the material thickness of the deformable first pipe section should be equal to or less than the thickness of the other

pipe sections. If the sections have a material thickness of 1 mm, the corrugated section may have a material thickness of 0.3-0.6 mm. The selected thicknesses and the relation therebetween is of course dependent on the size of the thermal movements, the dimensions of the pipes, the pressure of the flowing media and similarly related factors.

[0015] According to a further embodiment, the second pipe section of the inlet pipe has a cylindrical basic shape. The deformable section may be attached to the cylindrical pipe section upstream or downstream relative to the direction of flow. If the deformable section is placed downstream of the cylindrical section, then it is directly attached, preferably welded, to the collection channel going into the heat exchanger. If the pipe assembly includes a further, third cylindrical pipe section, then the deformable section may be attached in-between the second and the third pipe section.

[0016] According to yet a further embodiment, the second pipe section has a conical basic shape. The deformable section may be attached to the conical pipe section upstream or downstream in the direction of flow. If the deformable section is placed downstream of the conical section, then

it is directly attached, preferably welded, to the collection channel going into the heat exchanger. The conical pipe section is arranged to diverge in the direction of flow, whereby the diameter of the respective inlet and outlet is selected with respect to the flow rate, pressure or outlet velocity of the flow, and/or other related and desirable parameters.

[0017] According to a further embodiment, the combined inlet and outlet pipe joint is made up of two concentric pipes. In this case, the outer pipe joint may either have a cylindrical or conical cross-section. Both these embodiments of the outer pipe joint can be combined with any one of the embodiments of the inner pipe joint described above. In these cases, the average diameter of the corrugated section, as defined above, is preferably equal to the diameters of the adjoining pipe sections.

[0018] The material used for constructing the pipe arrangement is best chosen with respect to the field of application of the heat exchanger; that is, the type of heat emitting and absorbing medium, and the temperatures and pressure to which the pipe arrangement will be subjected. High temperatures and pressures will preferably require metallic materials, such as steel or aluminum of suitable thickness

and quality, while lower temperatures and pressures may allow the use of plastic pipes. Corrosive media may require particularly resistant materials. Joining of metallic pipes is preferably done by welding or soldering, while plastic materials and composites may be joined by welding, melting or gluing. Mechanical connections, such as threaded connections, are also possible, but will at the same time give a more space consuming, complex and therefore more expensive solution.

Brief Description of Drawings

[0019] In the following description, the invention will be described with reference to a number of preferred embodiments, as well as with regard to the attached drawings in which:

[0020] Figure 1 is a cross-sectional view showing schematically a recuperator, provided with a combined inlet and outlet pipe joint configured according to the present invention;

[0021] Figure 2 is a cross-sectional view showing a pipe connection of known configuration;

[0022] Figure 3 is a cross-sectional view showing an alternative embodiment of the invention; and

[0023] Figure 4 is a cross-sectional view showing a further alternative embodiment of the invention.

Detailed Description

[0024] Figure 1 shows a schematic representation of a recuperator comprising a heat exchanger packet 1 with a combined inlet and outlet pipe joint 2, 3, and a outgoing, first collection channel 4 with a pipe connection 5 between the collection channel and the outlet pipe joint 3. The combined inlet and outlet pipe joint 2, 3 comprises two concentric pipes forming channels for heat transporting media. The inner inlet pipe joint 2 is connected to a source of heat emitting medium, which in this illustrative case is combusted exhaust gas from a gas turbine which has not been shown. The mass flow of heat-emitting medium 6 flows through the heat exchanger in which a large portion of its heat energy is emitted to a heat-absorbing medium, which in this case is air. The heat-absorbing medium is collected in the outgoing, first collection channel 4, whereby the flow 7 is directed out through a pipe connection 5 to the outlet pipe joint 3 towards the gas turbine. According to this embodiment, the combined inlet and outlet joint comprises two concentric, partially conical channels. The inner pipe section, or the inlet pipe joint 2, is welded to an incoming, second collection channel 8 in the form of a diverging section or flange, which in turn is

attached to an upper casing 9 on the heat exchanger 1. The upper casing 9 conducts the heat-emitting medium in the direction of the flow channels (not shown) of the heat exchanger. A deformable pipe section 10 is attached to the inlet of the inner pipe section 2 and will be described in further detail in connection with Figure 4 below. The outer pipe section 3 is attached to the flange 8 at its inlet end, facing the heat exchanger, and to a not shown casing surrounding the gas turbine at its opposite end.

[0025] Figure 3 shows an alternative embodiment of a pipe connection. According to this embodiment, the combined inlet and outlet joint comprises a pair of concentric, cylindrical inner and outer pipe sections 2, 3. The inlet pipe joint 2 includes a deformable, substantially cylindrical, first pipe section 10, attached between a cylindrical second pipe section 2a and a cylindrical third pipe section 2b. The cylindrical second pipe section 2a is provided with a flange 11 for connecting it to a heat source, in this case a gas turbine (not shown), while the cylindrical third pipe section 2b is welded to the flange 8.

[0026] The deformable first pipe section has an inner diameter, D_1, corresponding to the smallest diameter of the corrugated section 10, which is equal to the inner diameter D_2

of the second section. Hence, in this case the average diameter D_M of the corrugated section is larger than the inner diameters of the pipe sections. The first pipe section 10 is provided with flanges 10a, 10b on either side of the corrugated section, which flanges are in contact with and welded to the outer periphery of the second and third section 2a, 2b respectively. During start-up of the plant, the temperature of the pipe joint will rise from a relatively low temperature, such as 20°C, to an operating temperature in excess of 600°C. The axial movement of the inner pipe section, in connection with thermal expansion of the material, to the extent it differs from that of the outer pipe section, will be taken up by the deformable pipe section 10.

[0027] As may be appreciated from Figure 3, the outer pipe joint 3 has a cylindrical basic shape along its outer periphery. However, it is slightly conical along its inner periphery, as the inner surface is coated with an insulating material 12 with a gradually increasing thickness. The reason for this is to minimize heat loss from the medium flowing in the direction of the gas turbine. The conical shape will also give certain flow-related advantages.

[0028] The embodiment of Figure 3 shows a deformable section

10 having a cylindrical section 2a, 2b on either side. It is, however, possible to eliminate one of these cylindrical sections, whereby the deformable section is placed at one end of a cylindrical pipe section.

[0029] Figure 4 shows a further alternative embodiment in the form of a pipe connection. According to this embodiment, the combined inlet and outlet pipe joint comprises a pair of conical inner and outer pipe sections 2, 3. The inner pipe section is provided with a deformable, substantially cylindrical first pipe section 10 attached to a cylindrical second pipe section. The cylindrical first pipe section is provided with a flange 11 for connection to a heat source, in this case a gas turbine (not shown), while the conical second pipe section is attached to the flange 8.

[0030] The deformable first pipe section has an inner diameter D_1, corresponding to the smallest inner diameter of the corrugated section, which is equal to the inner diameter D_2 of the adjoining second section. The first pipe section 10 is provided with flanges 10a, 10b on either side of the corrugated section, which flanges are in contact with and welded to the outer periphery of the second pipe section 2 and the flange 11, respectively. As can be seen from Figure 4, the inner surface of the outer pipe section is coated

with an insulating material with a gradually increasing thickness, for reasons stated above (cf. Fig. 3). In this case both the inner and the outer periphery of the outer pipe section has a conical shape. As in the case of the inlet pipe joint, the diameter of the inlet of the outer section is selected with respect to the flow rate, pressure or outlet velocity of the flow, and/or other related and desirable parameters.

[0031] According to a further alternative embodiment, it is also possible to position the deformable first pipe section 10 between the conical second pipe section 2 and the flange 8. Although the diameter D_1 of the pipe section 10 will be larger, such a positioning below the level of the inlet from the pipe connection 5 will cause less disturbance of the flow through the outlet pipe joint 3 as it passes the corrugations.

[0032] In addition, it is theoretically possible to position the deformable pipe section 10 between two conical pipe sections 2, in a way corresponding to that of Figure 3. However, due to differences in pressure between the different channels, as well as forces caused by thermal movements, the deformable section would be subjected to large stresses. Hence the embodiments described above are

preferable.